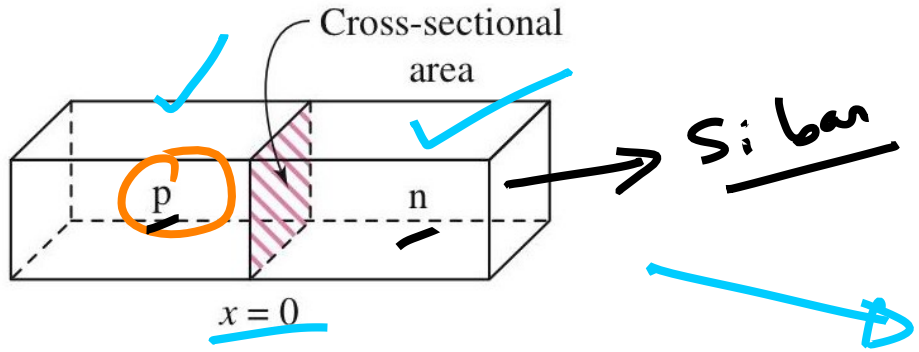
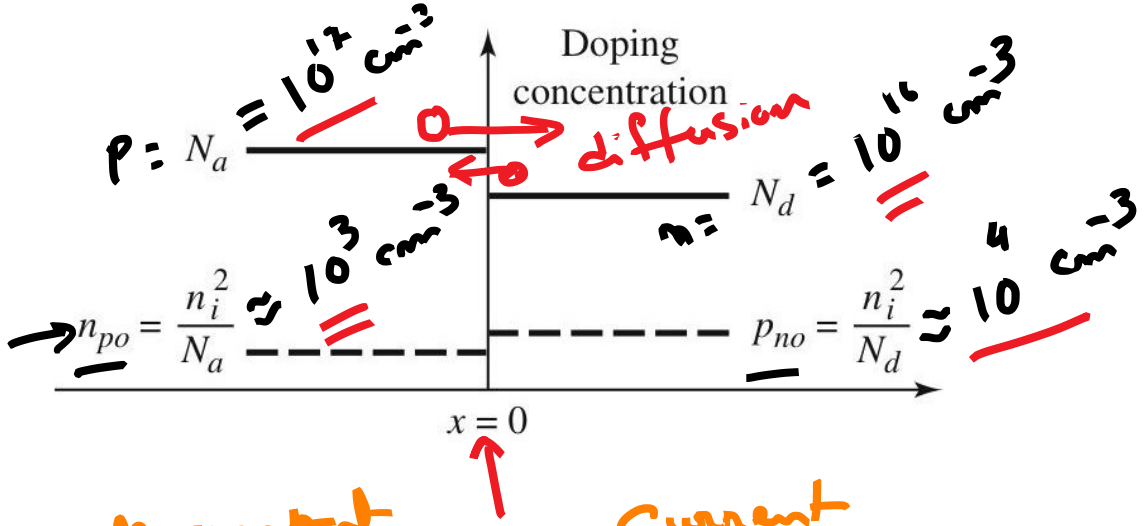
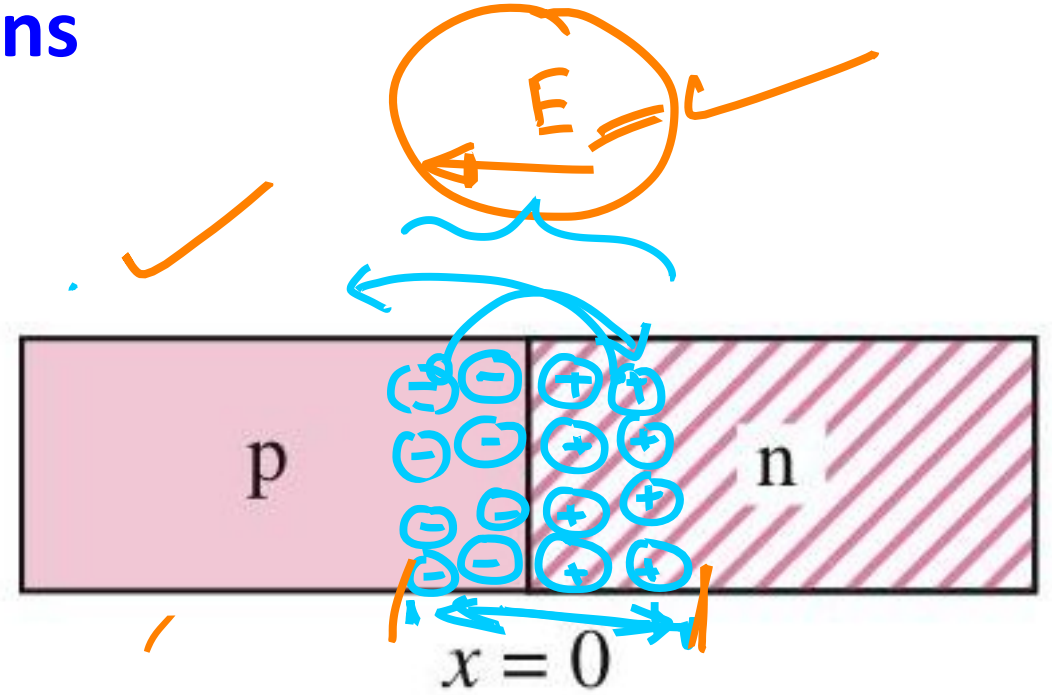
p-n junctions







$I = 0$

Movement

diff

Current

I_n diff

I_n diff

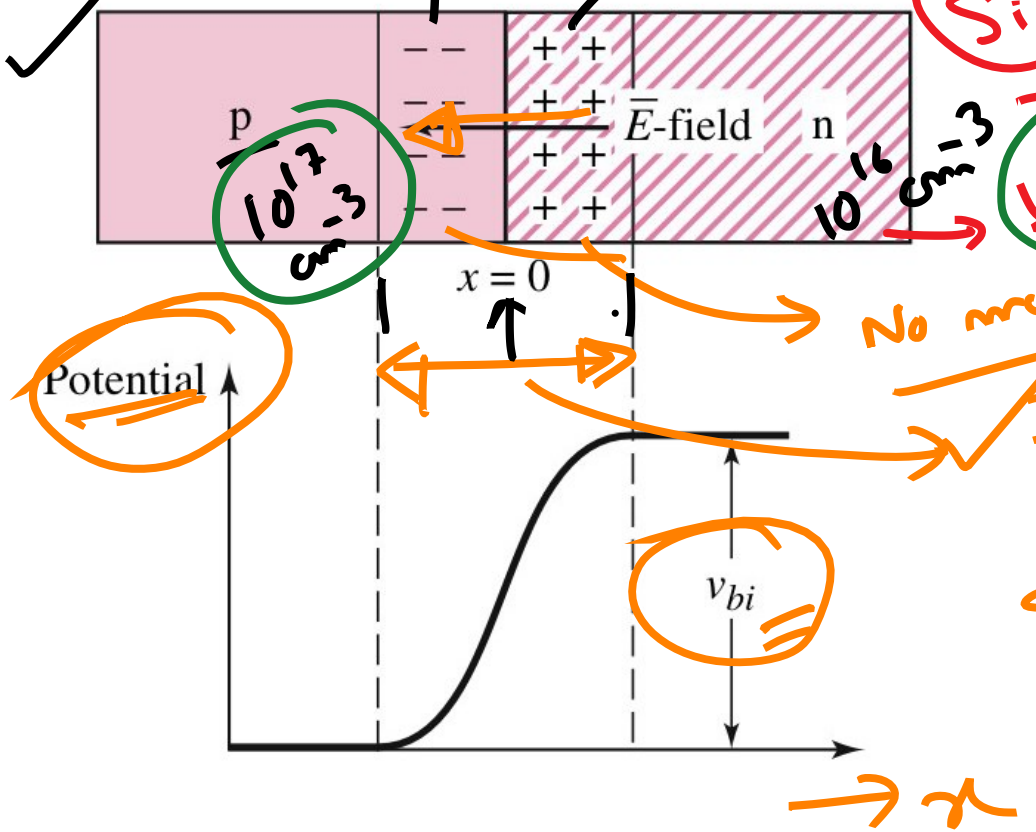
I_n drift

I_n drift

drift

Source: Electronic circuits: Analysis and Design –by D. A. Neamen, McGraw-Hill

Built-in potential in p-n junction



$V_{bi} = \frac{KT}{q} \ln\left(\frac{N_A N_d}{n_i^2}\right)$

$= V_T \ln\left(\frac{N_A N_d}{n_i^2}\right)$

$\rightarrow 0.026$ V at 300K

$E_g = 1.1$ eV

$V_{bi} \simeq 0.75$ V

$V_{bi} \simeq 0.81$ V.

No mobile charge region

Depletion region or space-charge region

for GaAs

$V_{bi} = \frac{KT}{q} \ln\left(\frac{N_A N_d}{n_i^2}\right)$

1.8×10^6 cm^{-3}

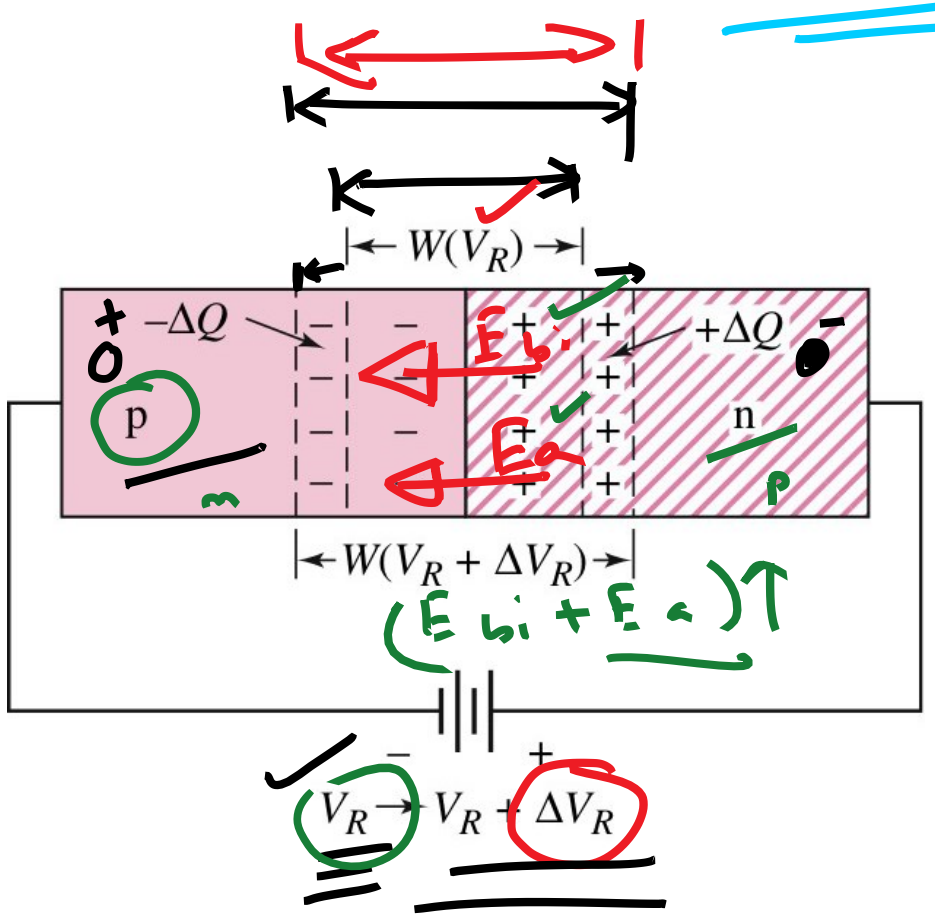
$\simeq 1.28$ V

$E_g = 1.4$ eV

$n_i \downarrow$

Source: Electronic circuits: Analysis and Design –by D. A. Neamen, McGraw-Hill

Reverse biased p-n junction



$$W = \left[\frac{2\epsilon (V_{bi} + V_R)}{q} \left(\frac{N_a + N_d}{N_a N_d} \right) \right]^{1/2}$$

$V_{bi} - V \rightarrow V_{bi} + V_R$

E_{bi} E_a

$(E_{bi} + E_a) \uparrow$

Current

Diffusion component ↓ ← increase in E

* drift component ??

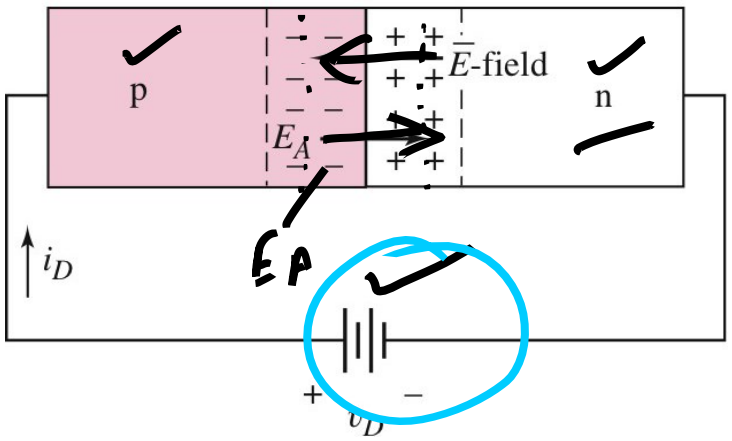
↓

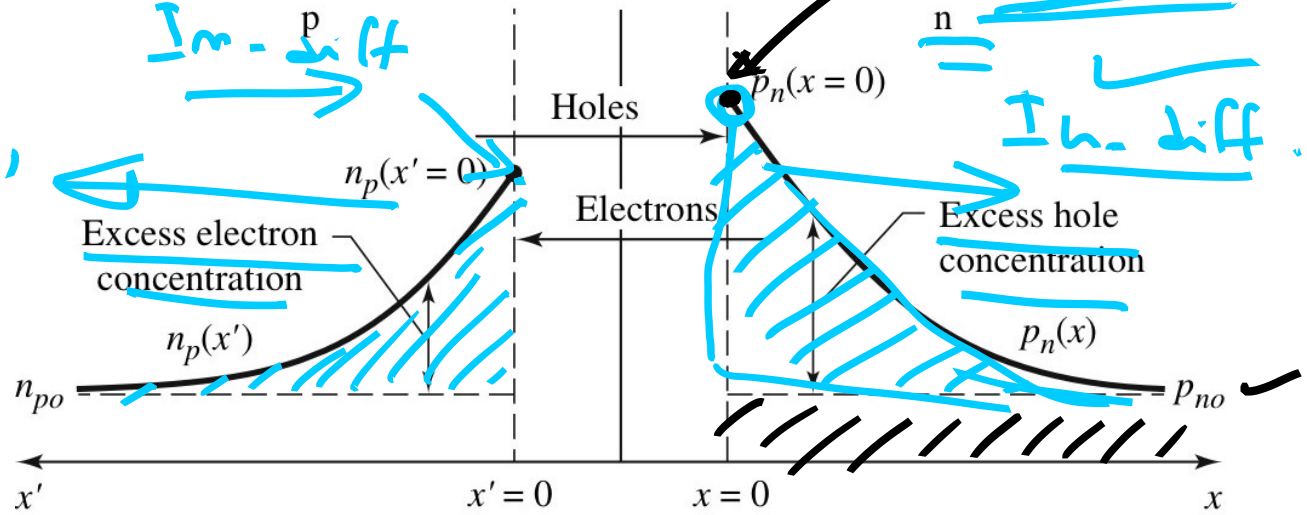
remains same

In reverse bias the p-n junc current is low and almost constant.

Source: Electronic circuits: Analysis and Design –by D. A. Neamen, McGraw-Hill

Forward biased p-n junction





$$I_D = I_S\left[\exp\left(\frac{V_D}{\eta V_T}\right) - 1\right]$$

I_D: Reverse saturation current ($\approx 10^{-10}$ A)

η: Ideality factor, $1 \le \eta \le 2$

V_T: Thermal voltage

I_S: Reverse saturation current

Source: Electronic circuits: Analysis and Design –by D. A. Neamen, McGraw-Hill

Current-voltage characteristics of p-n junction

$$I_D = I_S\left[\exp\left(\frac{V_D}{nV_T}\right) - 1\right]$$

$V_T \uparrow$ 0.026 V

Si. diode

$V_\gamma \approx 0.6\,V - 0.7\,V$

Reverse bias

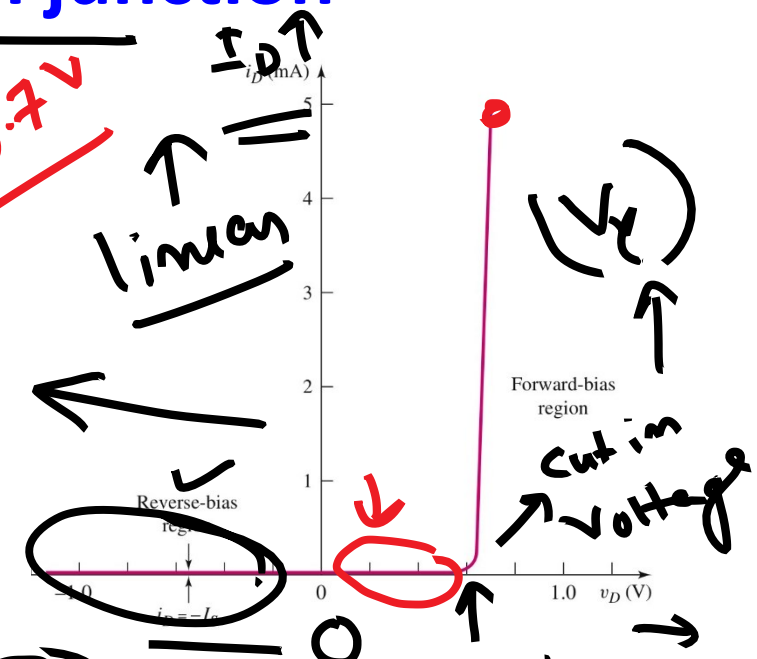
$$I_D \simeq -I_S$$

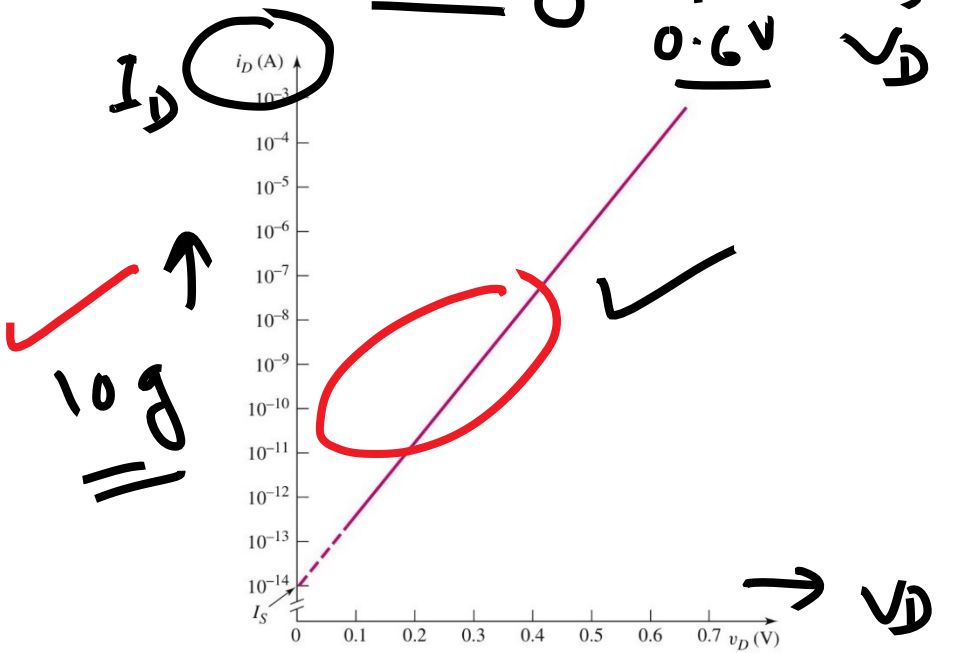
Forward bias

$V_D > 3V_T$

$$I_D = I_S \exp\left(\frac{V_D}{nV_T}\right) = I_S \exp\left(\frac{V_D}{V_T}\right)$$

$[n = 1]$





Source: Electronic circuits: Analysis and Design –by D. A. Neamen, McGraw-Hill